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Tube fossils from gossanites of the Urals VHMS deposits, Russia: Authigenic mineral assemblages and trace element distributions

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ABSTRACT

The occurrence, types, morphology, and mineralogical characteristics of tube microfossils were studied in gossanites from twelve VHMS deposits of the Urals. Several types of tube microfossils were recognized, including siboglinids, polychaetes and calcerous serpulids, replaced by a variety of minerals (e.g. hematite–quartz, hematite–chlorite, carbonate–hematite) depending on the nature of the substrate prior to the formation of the gossanites. Colonial hematite tube microfossils (~150 μm across,1–2 mm long) are composed of hematitic outer and inner walls, and may exhibit a cellular structure within their cavities. Spherical forms are saturated with Fe-oxidizing bacteria inside the tubes – probably analogues of trophosomes. Colloform stromatolitic outer wall surfaces are characterized by the presence of numerous interlaced filaments of hematite (2–3 μm diameter, up to 1–2 mm long). Between tube microfossils, the hematitized cement contains bundles of hematitized filaments with structures similar to the hyphae of fungi. Hematite–chlorite tube microfossils are scattered in gossanites, mostly as biological debris. They are typically 30 to 300 μm in diameter and 1 to 5 mm long. The layered structure of their tube walls is characterized by hematite–quartz and chlorite layers. Abundant filamentous bacteria coated by glycocalix and chlorite stromatolite are associated with hematite–chlorite tubes. The carbonate–hematite tube microfossils (up to 300 μm across, 2–3 mm long) occur in carbonate-rich gossanites. The tubes are characterized by fine (~10 μm thick) walls of hematite and cavities dominated by relatively dark carbonate or hematite. Carbonates may be present both in walls and cavities. Stromatolite-like leucoxene or hematite–carbonate aggregates were also found in association with tubes. Randomly oriented filaments are composed of ankerite. Single filaments are composed of individual cells, typically smaller than 100 nm across, similar to that of magnetotactic bacteria.

Three dimensional tomographic images of all types of tube microfossils demonstrate a clear wavy microlayering from outer and inner walls, which may reflect segmentation of the tube worms. The traces of burrowing or fragments of glycocalix with relict spheres are typical of tube microfossils from gossanites.

The carbon isotopic composition of carbonates associated with tube microfossils from hematite–quartz, hematite–carbonate, and hematite–chlorite gossanites average − 7.2, − 6.8, −22.8‰, PDB, respectively. These values are indicative of a biogenic origin for the carbonates. The oxygen isotopic composition of these carbonates is similar in all three gossanite types averaging + 13.5, + 14.2, + 13.0‰ (relative to SMOW), and indicative of active sulfate reduction during the diagenetic (and anadiagenetic) stages of the sediments evolution. The trace element characteristics of hematite from tube microfossils are characterized by high contents of following trace elements (average, ppm): Mn (1529), As (714), V (540), W (537), Mo (35), and U (5). Such high contents are most likely the result of metal and metalloid sorption by fine particles of precursor iron hydroxides during the oxidation of sulfides and decomposition of hyaloclasts via microbially-mediated reactions.

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